A Shoreline Nutrient Pollution Survey on Huffman Lake, 2006

By Tip of the Mitt Watershed Council

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SUMMARY

During June of 2006 the Tip of the Mitt Watershed Council conducted a nutrient pollution shoreline survey on Huffman Lake that was funded by the Huffman Lake Property Owners Association. Although nutrients are necessary to sustain a healthy aquatic ecosystem, excess can adversely impact an aquatic ecosystem, and indirectly poses a danger to human health. To determine if nutrient pollution was occurring in Huffman Lake, the entire shoreline was surveyed for nutrient pollution indicators and contributing factors.

Data collected during the shoreline survey indicates that nutrient pollution is probably occurring in Huffman Lake. Watershed Council staff traveled along the shoreline in kayak, as close to the shore as possible, documenting excessive algae growth and elevated conductivity, which are both indicators of nutrient pollution. After compiling field data and generating maps using GPS information, four areas of the lake appeared to be contributing relatively more nutrient pollution: the embayments in the northeast and southeast corners, the northern part of the west shoreline, and the western side of the southern shoreline. Although parameters surveyed indicate that nutrient pollution is occurring, factors such as wind, wave action, currents, and groundwater paths make it difficult to determine pollution sources with certainty.

To achieve the full value of this survey, it is recommended that the Association engage in follow-up activities aimed at educating riparian property owners about preserving water quality, and to help them rectify any problem situations. Summary information regarding the survey should be provided to all shoreline residents along with information about what each person can do to help, but specific information for individual properties should remain confidential. Individual property owners should be contacted confidentially and encouraged to participate in identifying and rectifying any problems that may exist on their property. Ideally, shoreline surveys should be repeated every 3-5 years as shoreline ownership, management, and conditions change continually.

INTRODUCTION

Background:

A shoreline survey to identify locations of potential nutrient pollution was conducted on Huffman Lake by the Tip of the Mitt Watershed Council during the summer of 2006. The entire shoreline was surveyed for *Cladophora* growth and for areas of elevated conductivity. The survey was funded by the Huffman Lake Property Owners Association.

Nutrient pollution can have adverse impacts on an aquatic ecosystem, and indirectly poses a danger to human health. Nutrients are necessary to sustain a healthy aquatic ecosystem, but excess will stimulate unnatural plant growth. Increased abundance of aquatic macrophytes (higher or vascular plants) can become a nuisance to recreation in shallow areas (typically less than 20 feet of depth). An increase in algal blooms also has the potential to become a recreational nuisance when algal mats and scum are formed on the lake's surface. However, algal blooms can also pose a public health risk as some species produce toxins including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Excess growth of both macrophytes and algae has the potential to degrade water quality by depleting the ecosystem's dissolved oxygen stores. Plants respire at night, consuming dissolved oxygen and thus, competing with other organisms and potentially depleting the water's oxygen supply. Furthermore, as vascular plants and algae die, the aerobic activity of decomposers has the potential to deplete dissolved oxygen supplies, particularly in the deeper waters of stratified lakes.

In general, small, shallow lakes such as Huffman are more sensitive to nutrient pollution. Large lakes with greater water volume have a bigger buffer and thus greater resistance to nutrient pollution. The large lakes tend to have greater dissolved oxygen stores and the greater volume allows for greater dilution of nutrients. By contrast, small lakes generally have smaller stores of dissolved oxygen, a lesser ability to dilute nutrients and therefore, are more susceptible to the indirect impacts of nutrient pollution. Small lakes with extensive shallow areas are at even greater risk as there is more habitat to support excessive aquatic macrophyte growth. Huffman Lake is a relatively small lake (~124 Acres) and fairly shallow (maximum depth = ~28 feet) and thus, particularly susceptible to nutrient pollution. However, Huffman Lake is a drainage lake with inflows and outflow, which provides a mechanism to flush excess nutrients out of the system.

Surface waters receive nutrients through a variety of natural and cultural sources. Natural sources of nutrients include stream inflows, groundwater inputs, surface runoff, organic inputs from the riparian (shoreline) area and atmospheric deposition. Springs, streams, and artesian wells are often naturally high in nutrients due to the geologic strata they encounter and wetland seepages may discharge nutrients at certain times of the year. Cultural (human) sources include septic and sewer systems, fertilizer application in riparian areas, and stormwater runoff from roads, driveways, parking lots, roofs, and other impervious surfaces. Poor agricultural practices, soil erosion, and wetland destruction also contribute to nutrient pollution. Additionally, some cultural sources (e.g., malfunctioning septic systems and animal wastes) pose a potential health risk due to bacterial and viral contamination.

Severe nutrient pollution is detectable through chemical analyses of water samples, physical water measurements, and the utilization of biological indicators (a.k.a., bio-indicators). Chemical analyses of water samples to determine nutrient pollution is effective, though costlier and more labor intensive than the other methods. Typically, samples are analyzed to determine nutrient concentrations (usually forms of phosphorus and nitrogen), but other chemical constituent concentrations can be measured, such as chloride, which are related to human activity and often elevated in areas impacted by malfunctioning septic or sewer systems. Physical measurements are primarily used to detect malfunctioning septic and sewer systems, which can cause localized increases in water temperature and conductivity (i.e., the water’s ability to conduct an electric current). Biologically, nutrient pollution is commonly detected by noting the presence of *Cladophora* algae. During the Huffman Lake shoreline survey, potential areas of nutrient pollution were identified by noting *Cladophora* growth and collecting water temperature and conductivity data.

Cladophora is a branched, filamentous green algal species that occurs naturally in small amounts in northern Michigan lakes. Its occurrence is governed by specific environmental requirements for temperature, substrate, nutrients, and other factors. It is found most commonly in the wave splash zone and shallow shoreline areas of lakes, and can also be found in streams. It grows best on stable substrates such as rocks and logs, though artificial substrates such as concrete or wood seawalls are also suitable. *Cladophora* prefers water temperatures in a range of 50 to 70 degrees Fahrenheit, which means that the optimal time for its growth and thus, detection, in northern Michigan lakes is from late May to early July, and from September and October.

The nutrient requirements for *Cladophora* to achieve large, dense growths are typically greater than the nutrient availability in the lakes of northern Michigan. Therefore, the presence of *Cladophora* can indicate locations where relatively high concentrations of nutrients, particularly phosphorus, are entering a lake. Although the size of the growth on an individual basis is important in helping to interpret the cause of the growth, growth features of *Cladophora* are greatly influenced by such factors as current patterns, shoreline topography, size and distribution of substrate, and the amount of wave action the shoreline is subject to. Therefore, the description has limited value when making year to year comparisons at a single location or estimating the relative amount of shoreline nutrient input. Rather, the presence or absence of any significant growth at a single site over several years is the most valuable comparison. It can reveal the existence of chronic nutrient loading problems, and help interpret the cause of the problems and assess the effectiveness of any remedial actions. Comparisons of the total number of algal growths can reveal trends in nutrient input due to changing land use.

Physical water measurements provide additional information to pinpoint areas of nutrient pollution caused by malfunctioning septic/sewer systems, but are particularly useful along lakeshore areas that do not have habitat suitable for *Cladophora* growth. If a septic system is malfunctioning due to mechanical failure or if a drainfield's capacity has been exhausted due to age, shallow groundwater is often contaminated and invariably migrates to adjacent surface water. Septic leachate tends to have high ion content due to dissolved substances in the waste water, such as salts. Increasing the number of ions in the water increases the conductivity and therefore, measuring conductivity in near-shore areas provides a feasible method for detecting septic leachate pollution. In addition, septic leachate pollution can be detected in areas of strong groundwater inputs by measuring water temperature, which may be elevated where contaminated by septic leachate.

The Watershed Council employs a system dubbed the "septic leachate detector" (SLD), whereby near-shore areas are monitored using a continuous flow pump system and a portable conductivity meter. This system has proven to work well for identifying shoreline areas polluted by septic leachate, but there are naturally occurring phenomena that can confuse the signal. For example, streams often have higher conductivity levels than lakes and therefore, strong differences in conductivity may be due to stream inlets on the lake shore. SLD surveys are usually conducted in the fall as septic contamination in shoreline areas is typically at its peak after heavy seasonal use.

According to Tip of the Mitt Watershed Council records, this survey provides the first comprehensive data set documenting shoreline nutrient pollution on Huffman Lake; a valuable data set that can be used as a lake management tool. Coupled with follow-up questionnaires and on-site visits, controllable sources of nutrients to the lake can be identified. Subsequently, a reduction in nutrient loading can often be achieved by working with homeowners to solve problems. These solutions are often simple and low cost, such as regular septic system maintenance, proper lawn care practices, and wise land use along the shoreline. Prevention of problem situations can also be achieved through the publicity and education associated with the survey. Periodic repetition of shoreline surveys is important for identifying chronic problem sites as well as recent occurrences. They are also valuable for determining long-term trends of near-shore nutrient inputs associated with land use changes, and for assessing the success of remedial actions.

Study area:

Huffman Lake is located in the northern Lower Peninsula of Michigan in the southeast corner of Charlevoix County. The entire lake falls within Hudson Township in Charlevoix County. Based upon shoreline digitizing on 2004 aerial photographs, the surface area of Huffman Lake is approximately 124 acres and the shoreline distance totals ~1.9 miles. The deepest point is located in the center of the lake and is reported to be from 26-30' deep.

Huffman Lake is a glacially formed kettle lake that sits at the headwaters of the Sturgeon River. There are at least two small inlet streams; a stream flowing into the northwest corner that connects to Kidney Lake to the west and a stream of unknown origin that flows in at a developed property on the west end of the south side of the lake. The only outlet is located in the northeast cove, which starts the West Branch of the Sturgeon River.

The Huffman Lake watershed is a sub-watershed of the Sturgeon River watershed, which is, in turn, part of the larger Cheboygan River Watershed. Huffman Lake has a large watershed in relation to the lake's surface area, measuring approximately 5,700 acres (does not include lake area). The watershed area to lake surface area ratio is ~46:1, which, compared to other lakes in Michigan, is quite high (e.g., Walloon Lake has a ratio of ~5:1). This ratio provides a statistic for gauging susceptibility of lake water quality to changes in watershed land cover. Essentially, the statistic indicates that the Huffman Lake watershed is large enough, relative to lake area, to provide a protective buffer, such that small areas of development will probably not negatively impact water quality. However, the cumulative impact of rampant landscape development throughout the watershed could have serious adverse impacts on the lake's water quality.

According to land cover statistics from a 2000 land cover analysis (NOAA, 2003), the majority of the watershed is forested. Of land cover types that typically contribute to water quality degradation, there is little urban/residential and a moderate amount of agriculture in the watershed (Table 1).

Table 1. Huffman Lake watershed land cover, 2000.

Land Cover Type	Acres	Percent
Agriculture	539.40	9.27
Barren	4.62	0.08
Forested	4296.33	73.86
Grassland	271.36	4.67
Scrub/Shrub	222.82	3.83
Urban/residential	94.71	1.63
Wetland	160.72	2.76
Water	226.87	3.90

According to data collected in programs coordinated by the Tip of the Mitt Watershed Council, Huffman Lake contains high quality waters that are typical for the region. As part of the Watershed Council's Comprehensive Water Quality Monitoring Program (CWQM), numerous parameters have been monitored in Huffman Lake on a triennial basis since 1995. Both dissolved oxygen and pH consistently comply with standards established by the State of Michigan (Table 2). Conductivity and chloride levels have remained low throughout monitoring, which indicates that there is little impact from urbanization and residential development. Typical of high-quality lakes in northern Michigan, nutrient concentrations on Huffman Lake have been quite low (total phosphorus, nitrate and total nitrogen).

Table 2. Huffman Lake data from the CWQM program.

	Temperature	DO	pH	Conductivity	Chloride	Nitrate	TN	TP
Units	˚Celsius	PPM	Units	microSiemens	PPM	PPB	PPB	PPB
Average	11.92	10.13	8.05	310.58	3.51	60.00	270.00	5.92
Minimum	6.95	7.03	7.58	303.00	3.00	10.00	165.00	2.40
Maximum	19.47	11.74	8.43	325.00	4.00	88.00	390.00	10.00
Range	6.95 - 19.47	7.03 - 11.74	7.58 - 8.43	303 - 325	3 - 4	10 - 88	165 - 390	2.4 - 10

*DO = dissolved oxygen, TN = total nitrogen, TP = total phosphorus, PPM = parts per million, PPB=parts per billion.

Based on data collected as part of the Watershed Council's Volunteer Lake Monitoring Program, Huffman Lake is classified as an oligotrophic lake (trophic status index values have ranged from 27 to 34). Oligotrophic lakes are characteristically deep, clear, nutrient-poor water bodies. Phosphorus data from the CWQM program supports this characterization as concentrations have typically been less than 10 parts per billion and have been dropping since monitoring began in 1995. However, Huffman Lake is not characteristically oligotrophic in that it is relatively shallow and not clear. In fact, water clarity, as measured with a Secchi disc has been decreasing over time (Figure 1).

Figure1. Chart of average Secchi disc depths in Huffman Lake.

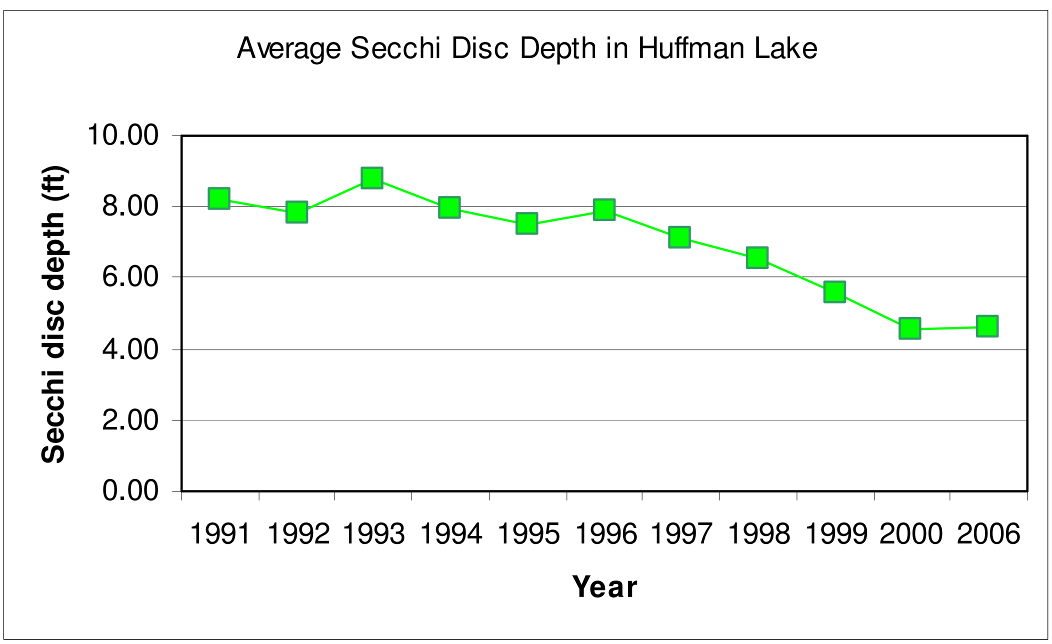
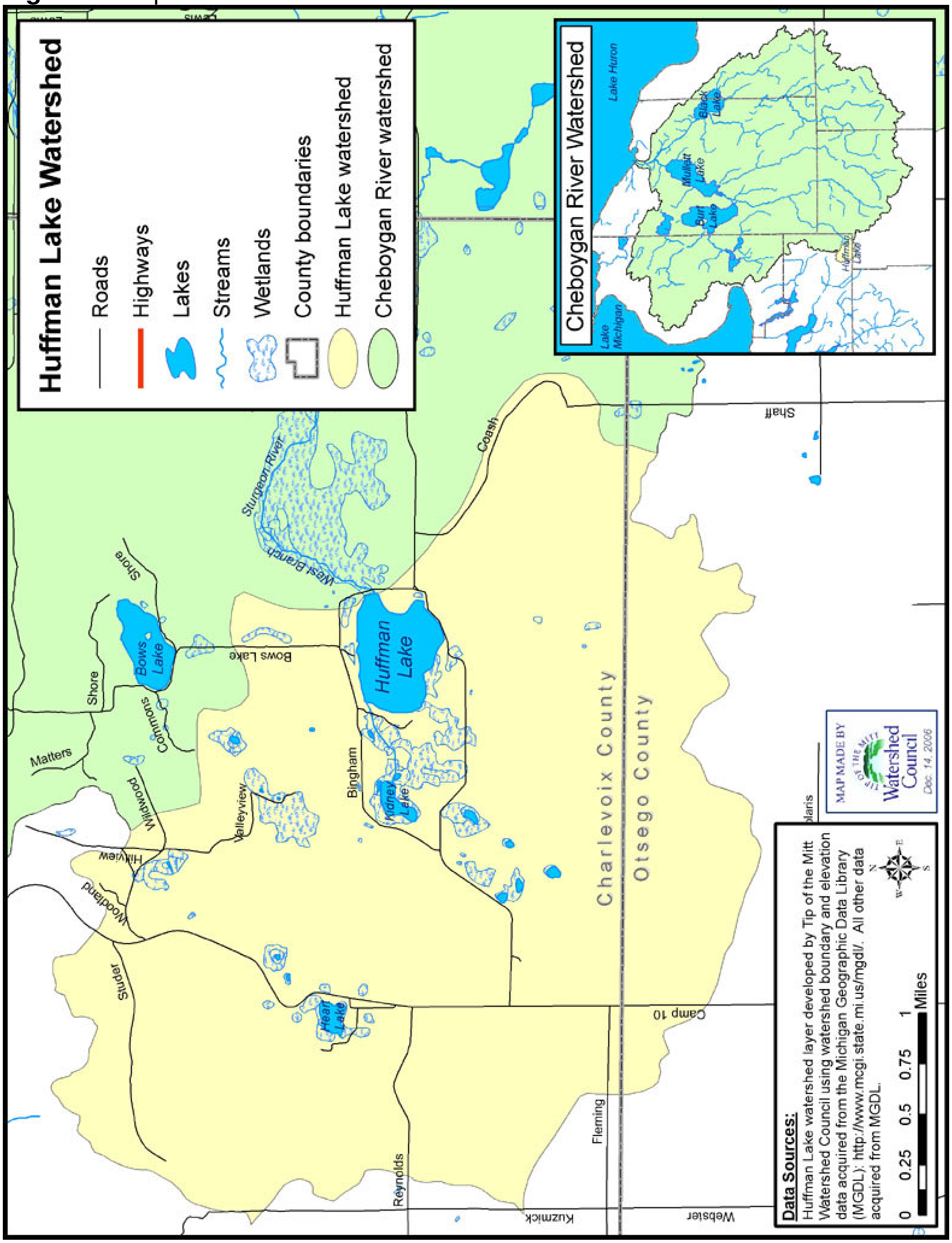


Figure 2. Map of the Huffman Lake watershed.



METHODS

The Huffman Lake shoreline was surveyed in kayak on June 12, 2006 to document signs of nutrient pollution. On a first pass around the lake, all shoreline parcels were photographed with a digital GPS camera and shoreline features were noted for each parcel. On a second pass, traveling as close to the shoreline as possible (usually within 20 feet), the entire shoreline was examined for the presence of *Cladophora* and near-shore waters monitored with the septic leachate detector. All information was recorded on field data sheets, subsequently inputted into a database, and used in conjunction with GPS data to link field data and photographs with property owner (equalization) data.

Shoreline Features

Shoreline property features were documented by taking pictures with a Ricoh Caplio Pro G3 GPS camera and by noting physical features on a data sheet, such as building descriptions, public access sites, and county road endings. Due to data sheet space limits, building descriptions were recorded in an abbreviated cryptic style. For example, *Red 2 sty, brn rf, wht trm, fldstn chim, lg pine* means that the property has a red two-story house with a brown roof, white trim, fieldstone chimney, and a large pine tree in the yard. Whenever possible, names of property owners and addresses were included.

Developed parcels were noted on field data sheets and included as a separate column in the database. Properties described as developed indicate the presence of buildings or other significant permanent structures, including roadways, boat launching sites, and recreational properties (such as parks with pavilions and parking lots). Properties with only mowed or cleared areas, seasonal structures (such as docks or travel trailers), or unpaved pathways were not considered developed. Additionally, relatively large parcels that may have development in an area far from the water’s edge were not considered developed. The length and area of developed versus undeveloped shoreline was not calculated.

Shoreline alterations were also noted during the field survey and included as a separate column in the database. Shoreline alterations (structures) were noted with the following abbreviated descriptions:

SB = steel bulkhead (i.e., seawall)
CB = concrete bulkhead
WB = wood bulkhead
BB = boulder bulkhead
RR = rock rip-rap
BH = permanent boathouse
DP = discharge pipe

Sometimes abbreviations were mixed or vary from what is listed above.

Tributaries are one of the primary conduits through which water is delivered to a lake or river from its watershed. Tributaries also carry and deliver a variety of materials from throughout the watershed to the receiving water. This can include pollutants such as sediment, nutrients, bacteria, and toxins from human activities far removed from a lake or river. *Cladophora* growths and elevated conductivity levels often occur at the mouth of tributaries. Therefore, tributary streams were documented during the survey, mapped with a Trimble GeoExplorer3 GPS unit, and included in a separate column in the database.

Additional information regarding shoreline property features or nutrient pollution that was written on field data sheets was also inputted into the database. This information was added to a column entitled “comments”.

Nutrient Pollution Indicators

Many species of filamentous green algae are commonly found growing in the nearshore regions of lakes. Positive identification of these species usually requires the aid of a microscope. However, *Cladophora* usually has an appearance and texture that is quite distinct to a trained surveyor, and these were the sole criteria upon which identification was based.

Other species of filamentous green algae can respond to an external nutrient source in much the same way as *Cladophora*, although their value as an indicator species is not thought to be as reliable. When other species occur in especially noticeable, large, dense growths, they are recorded on the survey maps and described the same as those of *Cladophora*.

Among other things, the distribution and size of each *Cladophora* growth is dependant on the amount of suitable substrate present. The extent of suitable substrate should therefore be taken into account when interpreting the occurrence of individual growths, and assessing the overall distribution of *Cladophora* along a particular stretch of shoreline. The presence or absence of suitable *Cladophora* growth substrate was recorded during the survey. In the database, properties with habitat throughout the shoreline were listed as "yes," without any habitat listed as "no," and those parcels possessing areas with habitat and other areas without habitat were listed as "partial".

When *Cladophora* was observed, it was described in terms of the shoreline length of the growth, relative growth density, and observed shoreline features potentially contributing to the growth. Shoreline length and growth density are subjective estimates. Growth density is determined by estimating the percentage of substrate covered with *Cladophora.* The categories and determinations for growth density are as follows:

Table 3. Categories and determinations for *Cladophora* density.

Density Category	**Field Notation**	**Substrate Coverage**
Very Light	(VL)	0% *
Light	(L)	1- 20%
Light to Moderate	(LM)	21-40%
Moderate	(M)	41-60%
Moderate to Heavy	(MH)	61-80%
Heavy	(H)	81-99%
Very Heavy	(VH)	90-100% *

**Very Light is noted when a green shimmer is noticed on hard substrate, but no filamentous growth present. Very Heavy overlaps with heavy and is distinguished by both high percentage of substrate coverage and long filamentous growth.*

A Trimble GeoExplorer3 GPS unit was used to map locations of very heavy *Cladophora* growth.

A septic leachate detector (SLD) was used during the second pass throughout most of the shoreline, but with particular focus on parcels that had no or partial *Cladophora* habitat. The SLD consists of a water pumping system that provides continuous flow to a chamber to measure the conductivity of the water. Using the SLD, water was pumped from as close to the shoreline as possible (usually within 1-2 feet) and conductivity levels were continually monitored to note changes from open water conductivity. Any increases or decreases were noted on data sheets.

Data Processing

Upon completing field work, all field data was transferred to computer. Information recorded on field data sheets was inputted into a Microsoft Excel® workbook. Digital photographs and GPS data were uploaded to a computer at the Watershed Council office and processed for use.

Maps were developed and field data linked to Charlevoix County equalization data by using GPS data collected in the field and a Geographical Information System (GIS). Parcel data acquired from the Charlevoix County GIS Department was used to produce a layer of Huffman Lake shoreline parcels. Using GPS field data for guidance, and working in a GIS, information in the workbook and digital photographs were joined to the County parcel data layer. This data layer was overlaid with other GIS data from the State of Michigan to produce the maps contained in this report.

Final products include a comprehensive database, a complete set of digital GPS photographs, and a GIS data layer of shoreline parcels. The shoreline survey database contains a sequential listing of properties beginning at the Hudson Township Park and traveling counter-clockwise around the entire perimeter of the lake. The database (Appendix A) contains all data collected in the field and identification numbers in the database correspond to those in the GIS data layer and on the hard-copy map. Digital photographs were named using the same identification numbers and are linked to the GIS data layer.

RESULTS

This survey documented shoreline conditions at 68 land parcels on Huffman Lake. Some portion of the shoreline was developed at 51 of these parcels (75%). Habitat generally considered suitable for *Cladophora* growth was present along at least part of the shoreline of 66 properties (97%). Noticeable growths of *Cladophora* or other filamentous green algae were found along the shoreline of 41 parcels (60%). The septic leachate detector revealed elevated conductivity levels in front of six parcels (9%).

In the field *Cladophora* growth densities were noted in seven different categories, but subsequently reduced to three categories to facilitate data examination. At properties where *Cladophora* growth was observed, there were an equal number of light and moderate growths (Table 4). Over 20% of observed growths were in the heavy category, one of which was noted as very heavy. Most of the *Cladophora* growths were associated with developed shoreline properties (~90%), though growths were also noted at 24% of undeveloped properties.

Table 4. Number and percent of properties per *Cladophora* density category.

Density Category	Number of Properties	Percent of Properties
Light	16	39
Moderate	16	39
Heavy	8	22

Of the six properties determined to have elevated conductivity using the SLD, five were located in the southeast corner of the lake along Huffman Lake Road and the remaining was in the northeast corner. All but one of the properties exhibiting elevated conductivity readings also had documented *Cladophora* growth. An interesting facet of the SLD survey is that the majority of parcels around the lake showed lower conductivity in shoreline areas than in open water (63%).

Maps made using GPS data and GIS software were reviewed to determine patterns in the occurrence of *Cladophora* growth and elevated conductivity levels (Figure 3). There did not seem to be any clear pattern as growths of varying densities occurred through all sides of the lake. However, there are four areas of the lake that may be contributing relatively more nutrient pollution. These include the embayments in the northeast and southeast corners, the northern part of the west shoreline, and the western side of the southern shoreline. The heaviest *Cladophora* growth was found in the northeast corner and the area of greatest overlap between *Cladophora* growth and elevated conductivity levels was in the southeast corner. Although parameters surveyed indicate that nutrient pollution is occurring, factors such as wind, wave action, currents, and groundwater paths make it difficult to definitively determine pollution sources.

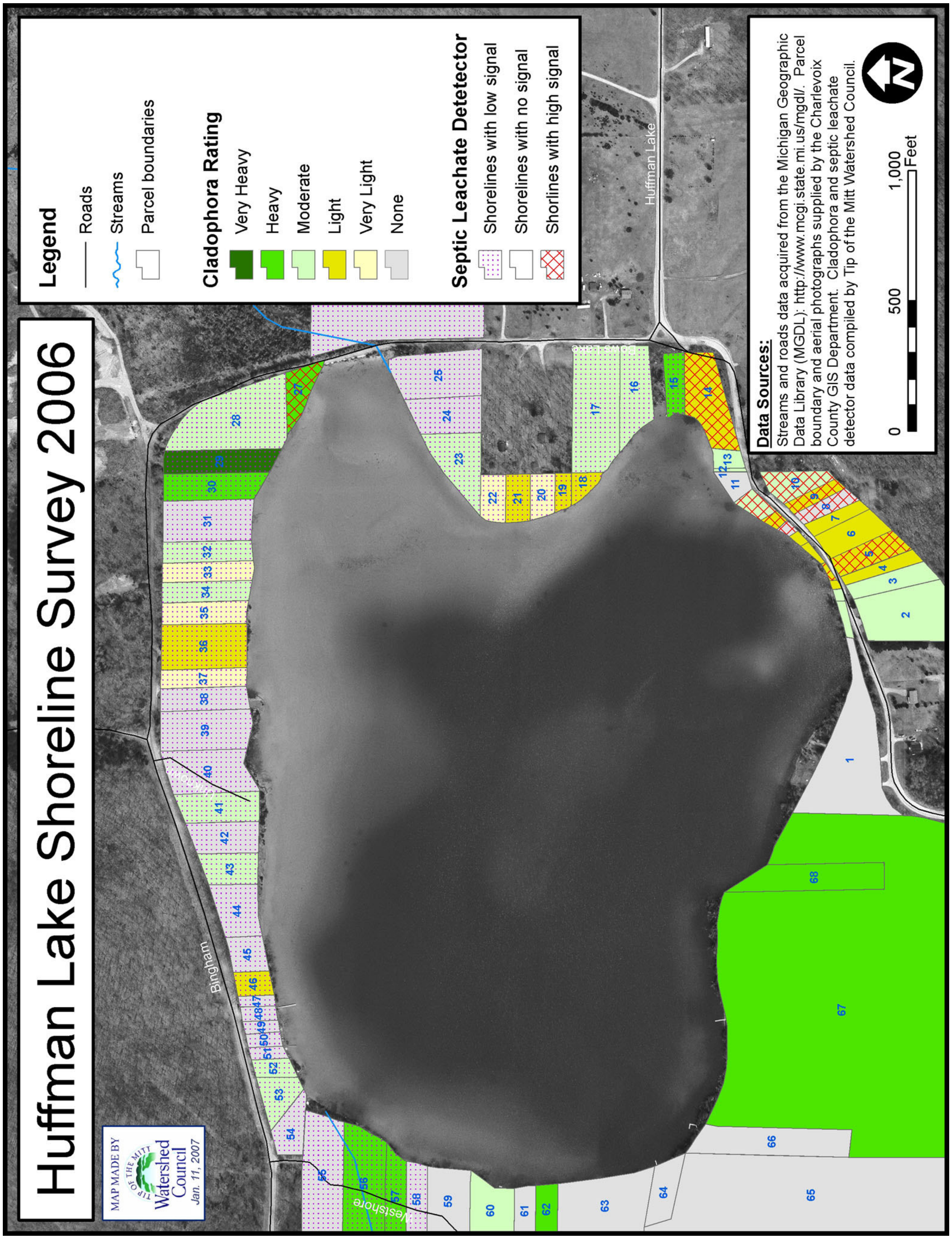
Only two tributary streams were documented during the survey. An inlet stream was noted on parcel 67 in the southwest and the outlet to the Sturgeon River was noted on parcel #26 in the northeast corner. According to maps, there is at least one more inlet tributary in the northwest corner (parcels #65 & 66), which was probably overlooked due to the dense shoreline vegetation occurring in that shoreline area.

Some form of shoreline alteration was noted at 76% of properties surveyed (Table 5). Most shoreline alterations consisted of riprap.

Table 5. Number and percent of various alterations on shoreline properties.

Alteration Type	Number	Percent
Boulder Riprap	9	13.24
Riprap	32	47.06
Riprap and wood	7	10.29
Wood	2	2.94
Barrels	2	2.94
None	16	23.53
Total	68	100.00

Figure 3. Map of Huffman Lake Shore Survey 2006 results.



DISCUSSION

Several areas along the Huffman Lake shoreline show evidence of potential nutrient pollution. Although some of the algae growth and elevated conductivity levels are undoubtedly associated with septic system leachate or other factors associated with development and human activities, others are probably due to natural factors. There are streams, springs and seeps flowing into Huffman Lake at different points along the shoreline that may be delivering nutrients and ions and which naturally increase algal growth and conductivity.

Water quality monitoring programs conducted on Huffman Lake provide further evidence that nutrient pollution is occurring. Nutrient pollution usually results in algal blooms, which decreases water clarity. Data collected in the Tip of the Mitt Watershed Council Volunteer Lake Monitoring Program shows that water clarity has decreased substantially since the early 1990s. Unfortunately, algal biomass data has not been consistently collected in the Volunteer Lake Monitoring program, so it cannot be determined whether water clarity has decreased as a result of increased algae or increased sediments in the water column.

Data collected using the SLD provided questionable results and therefore, may not be reliable. During past shoreline surveys on other lakes throughout the region, conductivity levels that are lower than open water levels are occasionally encountered, but generally in small isolated pockets. Lower conductivity along the shoreline can occur naturally due to heavy groundwater or stream inputs with low ionic content. However, there is some uncertainty as to whether this phenomenon could occur along such an extensive length of shoreline (63% of parcels) and therefore, suspicions regarding the reliability of the data. Another explanation could be equipment failure. The atypical results from the SLD portion of the survey should be considered when reviewing survey results.

Recommendations

The full value of a shoreline survey is only achieved when the information is used to educate riparian property owners about preserving water quality, and to help them rectify any problem situations. The following are recommended follow-up actions:

1. Keep the specific results of the survey confidential (i.e., do not publish a list of sites where filamentous algae or high SLD readings were found) as some property owners may be sensitive to publicizing information regarding their property.

2. Send a general summary of the survey results to all shoreline residents, along with a packet of informational brochures produced by the Watershed Council and others to provide information about dangers to the lake ecosystem and public health as a result of nutrient pollution as well as practical, feasible, and effective actions to protect water quality. This would cost approximately $5 to $25 per household, depending on the complexity and type of materials distributed.

3. Inform owners of properties with *Cladophora* growths or SLD signals of the specific results for their property, ask them to fill out a questionnaire in an attempt to interpret causes of the growth/signals, and offer individualized recommendations for water quality protection. Following the questionnaire survey, property owners have the option to contract the Watershed Council to perform site visits and even conduct ground water testing in an effort to gain more insight into the nature of the findings. Again, it should be stressed that all information regarding names, specific locations, and findings be kept confidential to encourage property owner participation in this project.

4. Repeat some version of the survey periodically (ideally every 3-5 years), coupled with the follow-up activities described previously, in order to promote water quality awareness and good management practices on an ongoing basis. During each subsequent survey, more information about shoreline features could be added to the database. The database will also facilitate future surveys, resulting in a reduction of staff hours needed for repeating the survey, and can be utilized for other water resource management applications.

5. Verify links made between shore survey results and land parcel data to ensure that information is being properly reported. Shoreline residents can assist the Watershed Council in determining if house descriptions in survey database match correctly with County land owner information. By doing so, property owners will receive the correct information regarding their parcel. This information is also useful for empowering the lake association to monitor shoreline activities, recruit new members, and compile and manage other water resource information.

6. Continue to support the Tip of the Mitt Watershed Council Volunteer Lake Monitoring program by providing volunteer support. The information collected by volunteers is extremely valuable for evaluating long-term trends and determining causes of change in water clarity. The Association is encouraged to continue supplying volunteer help and volunteers should attend training sessions held by the Watershed Council to ensure that a complete set of quality data is being collected each year. In addition, the Association should consider funding the collection of phosphorus data by the volunteer monitor (probably less than $50 per year for water chemistry analyses).

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Appendix A. Shore survey database.

ID	Developed	Property Description	Habitat	*Cladophora* 2006
1	No	Boat launch - Hudson Twp Park	P	None
2	Yes	Brn vert. log, grn rf, deck w/ lattice lower	P	Mx20 @ barrels & Mx10-15 @ rocks
3	Yes	Off-wht, wht&grn trim, brn lower, red deck @ water	Y	Lx70 (Mx20 @ dock&steps)
4	Yes	Blue vert. log, brn rf, wht trim, red deck, on hill	P	Lx20 @ log
5	Yes	Tan vert log, red rf, mtl trim	P	Lx10 - center
6	Yes	2-stry, brn, balcony, 55 gallon drums, Felkers cottage	P	Lx10 south end, Lx10 barrels@stairs
7	Yes	Wht, grn trim, grey rf, red fence, sand box @ shore	P	Lx5 s. of deck, Lx5 n. end (erosion)
8	Yes	Wht, brn trim & rf, obscr, brn fence, lamp post	P	None
9	Yes	Sm wht, vert. log, blk chimn, concr stairs & undevel. to	P	Lx50 heavier on n. end & VLx50 in undevel.
10	Yes	Nat. stain wd siding, 2-stry, red rf, mtl chimn, lg. lot	Y	Mx70 s. end to DP (fertilizer?)
11	Yes	Gry, wd, across rd, obscr, sm deck near shore	Y	
12	Yes	Narrow slice of undeveloped	Y	L/M?
13	Yes	2-stry, beige, wht trim, angular, block foundation	Y	L/Mx40 RR @ south end
14	Yes	2-stry, blue upper, ylw lower, red rf, lg. deck, DP	P	Lx10 rocks to n. of dock
15	Yes	Sm blue, brn mtl rf, red/wht trim, dish	P	M/Hx10 @ stream
16	Yes	Tan cedar siding, grn wd upper, grey rf, fldstn chimn	Y	L/Mx15 dock to west (fertilizer?)
17	No	Undeveloped	Y	Mx10 @ stream
18	Yes	Brn stain wd, brn slant rf, low deck	Y	Lx20 center (fertilizer?)
19	No	Undeveloped	Y	Lx100 center
20	Yes	2-stry stain brn wd, red/brn trim, obscr	Y	VLx50 center, patchy
21	Yes	Sm grey/wht, brn trim, sm wd deck	Y	VLx30 s. end, Lx15 n. of beach
22	Yes	Obscr, 2-stry, A-frame, fldstn sides, wd trim,	Y	VLx10 center
23	Yes	Nat wd, grn trim, red rf, fldstn chimn, skylightx2	P	L/Mx10 s. end
24	No	Undeveloped	P	None
25	No	Undeveloped, outlet	P	None
26	No	Undeveloped, road	Y	None
27	Yes	Sm tan, wht trim, brn mtl rf (undevel to west?)	Y	Lx10 @ e. end, H/Mx50 @ n. end
28	Yes	Obscr, flagpole, gray lower, brn upper	Y	L/Mx30 @ e. end by rushes
29	Yes	Beige, brn trim, brn mtl rf, deck, flagpole	Y	VHx100 (entire shore-fertilizer?)
30	Yes	Sm gray, gray rf, wht trim,	P	Hx15 @ w. end - stream?
31	Yes	Sm wht, gray rf, mtl chimn, wht outbldg	Y	None
32	Yes	Obscr orange A-frame, wire-mesh outbldg	Y	L/Mx10 @ center east & Lx5 @ w. end
33	Yes	Drk brn, gray/mtl trim, flat rf, outbldg near shore	Y	VL patchy (fertilizer?)

ID	Developed	Property Description	Habitat	*Cladophora* 2006
34	Yes	Ylw, gray rf	Y	L/Mx30 (fertilizer?)
35	Yes	Gray/tan, blk rf, 2 gables	Y	VL patchy (fertilizer?)
36	Yes	2-story ylw, brn trim, red rf, deck	Y	Lx30 center (fertilizer?)
37	No	Undeveloped, clearing to backlot?	N	VLx30 @ clearing
38	Yes	Gray/brn, gray rf, brk chimn, recessed	P	None
39	No	Undeveloped	P	None
40	No	Undeveloped	P	None
41	Yes	Brn wd, brn rf, 2 wht garage doors	P	Mx15 @ center west
42	No	Undeveloped, mowed on w. end	P	None
43	Yes	Tan garage, red rf, mtl chimn, nearshore, house obscr	Y	L patchy, Mx15 & patchy garage to east
44	Yes	2-stry, brn wd, brn trim, balcony	P	None
45	No	Undeveloped	P	None
46	Yes	3-stry, wht, obscr, mtl shed	Y	Lx20 center
47	No	Undeveloped	Y	None
48	Yes	2-stry, gray, wht trim, mtchg lg barn bldg & shed	Y	None
49	Yes	Wht, red deck, tree (birch) in water	Y	None
50	Yes	Grn, brn trim, deck, grn wd stairs	Y	None
51	Yes	Blue, wht trim, brn deck, concr stairs	P	None
52	Yes	Grn upper, wht lower, brk chimn, wd balcony	P	L/Mx10 btw this and next
53	Yes	Beige upper, brk lower, wht/grn trim, red rf	P	L/Mx10 btw this and last
54	No	Undeveloped	P	None
55	No	Undeveloped	P	None
56	Yes	Beige, brn trim, red rf, long, brk lower, skylight	Y	H/Mx100 - entire shore (fertilizer?)
57	Yes	Off-wht, 2 stucco chimn, mtl trim, deck	Y	M/Hx10 center
58	Yes	2-stry brn stain wd & cedar shingle, drk brn trim, spltstn	N	None
59	No	Undeveloped	P	None
60	Yes	Obscr, 2-stry, blue/gray, wht trim, balcony	P	Mx10 n. end
61	Yes	Blue-gray lower, cear shingle upper, red trim, brk chimn	Y	None
62	No	Undeveloped	P	Hx15 @ n. end, Hx10 center
63	Yes	Red, wht trim, mtchg garage, lg lot	P	None
64	Yes	Sm red wht trim, blk rf, block chimn	P	None
65	No	Undeveloped	P	None
66	Yes	Obscr, brn wd shed, heavily wooded	P	None
67	Yes	Beige, grn trim, red rf	Y	Hx50 (80' E of prev.), Hx70 dock W, Hxpatchy 100+' E of
68	Yes	Obscr, sm deck @ waters edge, DP-4"	P	Hx20 on wd @ DP

ID	*Cladophora* Rating	SLD	Stream	Alteration	Comments
1	N	0	F	none	100' mowed to edge
2	M	0	F	o	55-gal drums
3	M	0	F	rr,wd	
4	L	0	F	rr	cinder block RR
5	L	5	F	none	natural shoreline, sand & wd
6	L	0	F	o	55-gal drums
7	L	0	F	rr,wd	
8	N	5	F	rr,wd	DP=2"
9	L	15	F	rr	Undeveloped both sides - same lot? SLD15 @ n. end
10	M	10	F	br	DP=12", corrugated mtl
11	N	0	F	br	considered part of adjoining lots when surveyed
12	M	0	F	rr,wd	same owner as lot to north, not surveyed separately
13	M	0	F	rr,wd	bldg near shore, seep @ s. end
14	L	5	F	rr	bldg near shore, DP=4" to N, lot includes undevelop. to north
15	H	-5	T	rr	
16	M	-5	F	rr	
17	M	-5	T	rr	
18	L	-5	F	rr	
19	L	-5	F	rr	Part of next?
20	VL	-5	F	rr	
21	L	-5	F	rr	fertilizer?
22	VL	-5	F	br	2 pix
23	M	-5	F	rr	2 pix
24	N	-5	F	none	
25	N	-5	T	none	several pix
26	N	-5	F	rr	Along road, 3 pix
27	H	15	F	rr	3 pix, SLD in front of house - fertilizer?
28	M	-7	F	br	"Deer Run Trail", shed @ shore
29	VH	-10	F	rr, wd	fertilizer?
30	H	-15	T?	rr	unsure of stream
31	N	-10	F	rr	undeveloped both sides?
32	M	-10	F	rr	
33	VL	-10	F	br	Don Kelly
34	M	-10	F	br	Don Kelly's son
35	VL	-10	F	br	Don Kelly's son

ID	*Cladophora* Rating	SLD	Stream	Alteration	Comments
36	L	-10	F	br	fertilizer? Lot includes undeveloped to east
37	VL	-10	?	none	Road end, could be stream
38	N	-5	F	rr	
39	N	-5	F	none	2 pix, wd
40	N	-5	F	none	wd, not surveyed separately in field
41	M	-10	F	rr	3 pix, lg lot, lots 40-42 same owner
42	N	-10	F	rr	wd, not surveyed separately in field
43	M	-10	F	br	3 pix, lg lot, fertilizer?
44	N	-10	F	rr	2 pix, fertilizer?, lots 43-45 same owner
45	N	-10	F	none	wd
46	L	-10	F	rr,wd	
47	N	-10	F	rr	same owner as lot to west, not surveyed apart in field
48	N	-10	F	rr	
49	N	-10	F	rr	
50	N	-10	F	rr	
51	N	-10	F	rr	
52	M	-10	F	rr	fertilizer?
53	M	-10	F	rr	fertilizer?
54	N	-10	T	none	wd, same owner as lot to NE
55	N	-10	T	none	wd
56	H	-10	F	wd	fertilizer?
57	H	-10	F	rr	fertilizer?
58	N	-10	F	none	
59	N	0	F	none	2 pix, wd
60	M	0	F	rr,s	sand beach, includes undevelop x 30 to south - wd
61	N	0	F	wd	
62	H	0	F	none	wd
63	N		F	rr	includes undeveloped pieces to north & south - wd
64	N		F	none	wd
65	N		F	none	wd, only corner of lot reaching lake
66	N		F	none	wd
67	H		T	rr	fertilizer? wd, lot continues E of next with Hx40 center
68	H		F	rr	